IN THE UNITED STATES PATENT AND TRADEMARK OFFICE



Declaration
G. Stanly
9-21-01

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| In re Application of | ) | |
| Jeff Dulaney et al. | ) | Group: |
| Serial No. 09/178,968 | ) | |
| Filed: October 26, 1998 | ) | Examiner: |
| Title: SINGLE MODE OSCILLATOR | ) | |
| FOR A LASER PEENING | ) | |
| LASER | ) | |

**DECLARATION OF DR. JEFFREY DULANEY**
**Pursuant to 37 C.F.R. § 1.131**

I, Dr. Jeffrey L. Dulaney, do hereby declare and say:

1. I am a named inventor of U.S. Patent application serial number 09/178,968 ('968).

2. I am the Chief Executive Officer and President of LSP Technologies, Inc., the Assignee of the '968 patent application.

3. I received a Bachelor of Science Degree in Physics from the University of Pittsburgh in 1986.

4. I hold some 15 patents in the area of laser peening technologies.

5. Well prior to August 13, 1998, the filing date of the 6,198,069 Hackel patent, myself and other LSPT personnel had completed a design and reduced to practice, in the United States, the single transverse mode laser claimed and described in the 09/178,968 patent application.

6. In accordance with our corporate practice, I communicated the essence of the design to our patent counsel in a letter facsimile dated April 24, 1998. A true and accurate copy of the letter is attached herewith. Redacted sections pertain to a confidential client name.

7. As can be seen from the document itself under the section entitled Single-mode oscillator, it related to Attorney Randall J. Knuth, our results of testing a laser peening system utilizing a single transverse mode to laser shock process surfaces of workpieces.

8. The letter to Attorney Knuth dated April 24, 1998 was the initial disclosure for drafting the above referenced U.S. Patent application serial number 09/178,968 which was filed October 26, 1998.

The undersigned, being hereby warned that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the Application or any registration resulting therefrom; that the facts set forth in this declaration are true; and that all statements are made of my own knowledge are true and all statements made on information and belief are believed to be true.

Sept 11, 2001
Date

By: Dr. Jeffrey L. Dulaney

Attachment: Copy of letter dated April 24, 1998.

Received: 4/24/98; 10:14AM; 6147183007 => KNUTH,P.C.; #1

PR.24.1998 10:19AM P 1

FROM : LSP TECHNOLOGIES INC PHO NO. : 6147183007



TECHNOLOGIES, INC.
6145B Scherers Place
Dublin, Ohio 43016-1272



April 24, 1998

Mr. Randy Knuth
3510-A Stellhorn Road
Fort Wayne, IN 46815

RE: LSP-18 Patent

Dear Randy:

Enclosed is a copy of the latest [redacted] patent for your reference. I am very surprised that this got through the patent office and it made us think that we should pursue a patent based on our current oscillator and some improvements. I will try to outline the invention first.

**<u>The dual-pump-cacity oscillator:</u>**
We are currently using a dual-pump-cavity-oscillator in both of our systems and in the three systems that we have supplied to [redacted] The basic configuration is shown in Figure 1 (HR is high reflectivity mirror, OC is output coupler). The big advantage of this oscillator is that the spatial profile remains substantially uniform and constant with time because of the stress birefringence compensation. Without compensation the spatial profile will be a Maltese cross pattern, which is undesirable for laser peening. We have sold three laser systems to [redacted] with this basis oscillator and the delivery of the first system was about three years ago. If there is some way that we could patent this oscillator as a source for laser peening, we should do it. There are published articles on this oscillator.

All of the [redacted] systems use a "hard iris" (in the 6-8 mm range); whereas, we have found that a "soft iris" or apodizer is preferable because it improves that spatial uniformity of the beam and it also decrease the divergence of the beam. The decreased divergence of the beam means that there is less variation in the spatial profile of the beam as it propagates through the system, making it easier to align and improving the spatial uniformity on the workpiece.

The disadvantage to this type of oscillator (and any other large aperture oscillator) is that the output beam is multi-transverse-mode. The multi-mode nature of large aperture oscillators inherently generates "hot spots" in the beam because of the interaction of the different modes. These hot spots can greatly decrease the lifetime of components in the beam path. Optical coatings typically begin to show damage within 10,000 shots and must be replaced within 100,000 shots. That makes the maintenance costs enormous.

**<u>Single-mode oscillator:</u>**
We have found that by making the oscillator operate in a single transverse mode, the lifetime of the components is increased by a large amount. Our data shown that we do not see damage until about 50,000 shots, at an energy density twice the normal level. We believe that this should mean that the lifetime of components under our normal operating conditions will be extended to at least 500,000 shots and possibly as high as 2,000,000 shots. This will mean an enormous savings in maintenance costs and probably make laser peening cost effective for many more applications.

The easiest way to make the oscillator single mode is to reduce the iris size to about 2 mm (we could claim ≤ 5 mm). So Figure 1 is still valid, except that the iris is small. Figures 2 & 3 show alternative single mode oscillators.

**<u>Rough cut at the claims:</u>**

1. A method for laser peening a workpiece, the method comprising:
   - generating a laser pulse from a substantially single-transverse-mode oscillator;
   - modifying said laser pulse with a pulse sharpening device,
   - means for amplifying said laser pulse, and
   - directing said laser pulse to the workpiece.
2. The method of claim 1 wherein said oscillator also provides means for compensating for stress birefringence.
3. The method of claim 2 wherein said oscillator comprises a dual-pump-cavity configuration with a 90 degree rotator between the pump cavities.
4. The method of claim 2 wherein said oscillator further comprises a porro prism
5. The method of claim 1 wherein said oscillator also provides means for generating a single-longitudinal-mode laser pulse.
6. The method of claim 5 wherein said means for generating a single-longitudinal-mode is a seed laser.
7. The method of claim 5 wherein said means for generating said single-longitudinal-mode laser pulse is an etalon.
8. The method of claim 1 wherein said oscillator contains and aperture with an opening of less than 5 mm.
9. The method of claim 1 wherein said oscillator is an unstable oscillator.
10. The method of claim 9 wherein said unstable oscillator is produced by a gradient reflector.
11. The method of claim 1 wherein the gain medium of said oscillator is pumped by an external laser source to produce said single-transverse-mode.
12. The method of claim 1 wherein said pulse sharpening device is an electro-optical pulse slicer.
13. The method of claim 12 wherein said pulse sharpening device is used to modify both the leading edge and the trailing edge of said laser pulse.
14. The method of claim 1 wherein said pulse sharpening device is a phase conjugation cell.
15. The method of claim 1 wherein said amplifying means is a series of Nd:glass amplifiers.
16. The method of claim 1 wherein said amplifying means is a multi-pass amplifier
17. The method of claim 16 wherein said multi-pass amplifier comprises a phase conjugation device and a means for birefringence compensation.
18. The method of claim 15 wherein said amplifying means further comprises a means for birefringence compensation of the laser pulse as said laser pulse passes through said amplifying means.
19. The method of claim 18 wherein said means for birefringence compensation is a 90 degree rotator.
20. A apparatus for laser peening a workpiece, said apparatus comprising:
    - a substantially single-transverse-mode laser oscillator;
    - a laser pulse-sharpening device,
    - means for amplifying a laser pulse, and

- a laser peening cell.

21. The method of claim 20 wherein said oscillator also provides means for compensating for stress birefringence.
22. The method of claim 21 wherein said oscillator comprises a dual-pump-cavity configuration with a 90 degree rotator between the pump cavities.
23. The method of claim 21 wherein said oscillator further comprises a porro prism
24. The method of claim 20 wherein said oscillator also provides means for generating a single-longitudinal-mode laser pulse.
25. The method of claim 24 wherein said means for generating a single-longitudinal-mode is a seed laser.
26. The method of claim 24 wherein said means for generating said single-longitudinal-mode laser pulse is an etalon.
27. The method of claim 20 wherein said oscillator contains and aperture with an opening of less than 5 mm.
28. The method of claim 20 wherein said oscillator is an unstable oscillator
29. The method of claim 28 wherein said unstable oscillator is produced by a gradient reflector.
30. The method of claim 20 wherein the gain medium of said oscillator is pumped by an external laser source to produce said single-transverse-mode.
31. The method of claim 20 wherein said pulse sharpening device is an electro-optical pulse slicer.
32. The method of claim 31 wherein said pulse sharpening device is used to modify both the leading edge and the trailing edge of said laser pulse.
33. The method of claim 20 wherein said pulse sharpening device is a phase conjugation device.
34. The method of claim 20 wherein said amplifying means is a series of Nd:glass amplifiers.
35. The method of claim 20 wherein said amplifying means is a multi-pass amplifier.
36. The method of claim 35 wherein said multi-pass amplifier comprises a phase conjugation device and a means for birefringence compensation.
37. The method of claim 34 wherein said amplifying means further comprises a means for birefringence compensation of the laser pulse as said laser pulse passes through said amplifying means.
38. The method of claim 37 wherein said means for birefringence compensation is a 90 degree rotator.

Let us know what you think. How quickly can we get this filed. Should we quick file?

Thanks for all of your hard work and continued support.

Best Regards,

Jeff L. Dulaney, Ph.D.
President